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$$u = \frac{1}{9} \left( \frac{(1337 + 215\sqrt{33})4\pi c^2}{9} \right)^{\frac{1}{2}} [(3298 - 450\sqrt{33})^{\frac{1}{2}} - 2].$$

# MECHANICS.

116. Proposed by C. L. CHILTON, Greensboro, Ala.

Given, the shaft  $ABC$  attached at one end by a pivot to the piston-rod of an engine (at  $A$ ) and the other to a crank of the wheel  $CDE$  (at  $C$ ). The shaft moves through the distance of two feet in one second from  $A$  to  $B$  and at the same time turns the crank from  $C$  to  $E$ . The force propelling the shaft along the constrained course from  $A$  to  $B$  is 5760 pounds. The mass of the rod and wheel and friction being not considered, what would be the kinetic energy of the machine? or the sum of the moment around  $O$ , the center of the wheel?

Solution by G. B. M. ZERR, A. M., Ph. D., Professor of Chemistry and Physics, The Temple College, Philadelphia, Pa.

Let  $AC$ , the connecting rod  $= l$ ,  $OC = r =$  one foot,  $\angle AOC = \theta$ , force 5760 pounds along  $AO = P$ , component of  $P$  along  $AC = Q$ . Then moment of crank effect about  $O = Q \cdot OM$ . In the right triangles  $AOM$ ,  $AON$ ,  $AO:OM = AN:ON$ .

$$\therefore P:OM = Q:ON.$$

$$\therefore Q \cdot OM = P \cdot ON.$$

$$\text{Also } ON:OC = \sin OCN:\sin ONC.$$

$$\text{Let } \angle OAC = \varphi. \text{ Then } \angle ONC = \frac{1}{2}\pi - \varphi, \angle OCN = \theta + \varphi.$$

$$\therefore ON = \frac{r \sin(\theta + \varphi)}{\cos \varphi} = r \sin \theta + \frac{r \cos \theta \sin \varphi}{\cos \varphi}.$$

$$\text{but } \sin \varphi = \frac{r \sin \theta}{l}. \therefore ON = r \sin \theta + \frac{r^2 \sin \theta \cos \theta}{\sqrt{(l^2 - r^2 \sin^2 \theta)}}.$$

$$\therefore \text{moment} = Pr \sin \theta \left( 1 + \frac{r \cos \theta}{\sqrt{(l^2 - r^2 \sin^2 \theta)}} \right).$$

Now  $\theta$  varies from 0 to  $\pi$ .

$$\therefore \text{Average moment} = \frac{Pr \int_0^\pi \sin \theta \left( 1 + \frac{r \cos \theta}{\sqrt{(l^2 - r^2 \sin^2 \theta)}} \right) d\theta}{\int_0^\pi d\theta} = \frac{2Pr}{\pi},$$

a result independent of the connecting rod.

$$2Pr/\pi = .6366Pr = 3666.816 \text{ or } 3667 \text{ pounds.}$$

117. Proposed by F. P. MATZ, M. Sc., Ph. D., Professor of Mathematics and Astronomy in Irving College, Mechanicsburg, Pa.

How much lower must *one end* of a heavy uniform chain, wound round the circumference of a perfectly rough vertical wheel, hang than *the other end*, when the chain is on the point of motion?

